THE DEALFISHES (TRACHIPTERIDAE) OF THE MEDITERRANEAN AND NORTH-EAST ATLANTIC

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THE DEALFISHES (TRACHIPTERIDAE) OF THE MEDITERRANEAN AND NORTH-EAST ATLANTIC

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(With 3 Text-figs.)

SUMMARY

1. The species of *Trachipterus* occurring in the Mediterranean and north-east Atlantic are reviewed.
2. *Trachipterus cristatus* is considered to be generically distinct and is placed in a separate genus.
3. *Trachipterus gryphurus* Lowe is regarded as a synonym of *T. arcticus* and *T. pentastigma* Norman as a synonym of *T. trachypterus*.
4. Comments are made on the young stages, sexual dimorphism and food of Trachipterids.
5. A brief description of the swim bladder is given.

INTRODUCTION

The systematics of the fishes of the genus *Trachipterus* (s.l.) are in a somewhat confused state, the main reason for this being that these fishes are comparatively rare in museum collections. Their fragility is such that few unmutilated examples have been available for study, and many of the nominal species have been described from single specimens. Furthermore, it is known that allometric growth occurs at certain stages, the extent of which has not been fully investigated.

The present paper has resulted from the difficulty experienced in identifying a juvenile example from the Orkneys.*

The Dealfishes are widely distributed and are known to occur in the Arctic, Atlantic, Indo-Pacific and Mediterranean regions. Some thirty nominal species have been described, but the work I have done on this family suggests that there may be comparatively few species, each having a fairly wide geographical range.

In 1861 Günther listed nine species of *Trachipterus*, eight of which were said to occur in the Mediterranean and north east Atlantic. Since that time an additional fifteen species have been described from various localities, including two from the area under consideration, these latter being *T. filicauda* Costa (1862) and *T. gavardi* Bounhiol (1923).

* For a comprehensive study of the order Allotriognathi, reference should be made to a series of papers to be published by Walters and others.

In his work on the young stages of *T. taenia*, Emery (1878–79) was able to demonstrate for the first time the changes that take place in these fishes during successive growth stages and on the basis of this work came to the conclusion that *T. filicauda*, *T. spinolae*, *T. taenia* and *T. trachypterus* were synonymous, being different growth stages of the same form.

Lütken (1881) reduced still further the number of species and to-day it is generally accepted that only three taxons should be recognized from the Mediterranean and NE. Atlantic areas. These are *T. arcticus*, a northern form, and *T. trachypterus* and *T. cristatus*, both more southerly species. *T. cristatus* differs so markedly from the other two species that it warrants generic status. Walters and Fitch (1960) have reached the same conclusion and I shall consequently be using their name in preference to that which I was proposing to use.

The only other species which has been recorded from the North Atlantic is *T. trachyurus*, described by Poey (1856–58). This is known only from the type, taken off Cuba, and one other specimen taken off Florida in 1952, and appears to be confined to the western North Atlantic. This species is quite distinct from both *T. arcticus* and *T. trachypterus*, differing in the lower dorsal ray count (82) and in the form of the gill-rakers, which in *T. trachyurus* lack the fringe of bristle-like setae found in the other species.

In the past, the keys which have been provided for the distinction of the species have been based largely on descriptions and not on an examination of actual specimens. As an example, Goode and Bean (1896) ignored the work of Emery and Lütken and gave a key to a number of species, which had been adapted from an earlier work by Moreau (1881). More recently, Lozano y Rey (1947) and Smith (1949) have given keys for the three forms currently recognized from this area.

As the species of the genus *Trachipterus* (s.l.) here considered are now placed in two genera, the following key for their separation has been included.

Key to the Mediterranean and N.E. Atlantic Genera

1. Body scaleless; ventral profile not constricted behind vent. Lower rays of caudal fin reduced to stumps in adults. Vertebrae 84 to 102. No bulbous flaps on fin-rays at any stage. Colour pattern uniform silvery or brown, with usually 1 to 5 large dark blotches along sides of body . . . . . *Trachipterus*
2. Deciduous cycloid scales present on body. Ventral profile crenulate and sharply constricted behind the vent. Lower caudal rays not so reduced as in *Trachipterus*. Vertebrae 62 to 69. Bulbous flaps present on dorsal and pelvic rays in young stages. A number of dark transverse markings along the trunk and caudal regions *Zu*

Trachipterus Gouan

Trachipterus Gouan, 1770. *Hist. Pisc.*: 104 and 153 (*Cepola trachyptera* Gmelin).
Gymnogaster Brünnich, 1788. *K. Dansk. vid Selsk.* **3**: 408 (*arcticus*).
Trachypterus Schneider, 1801. *Blochii Syst. Ichth.*: 480 (*taenia*).
Bogmarus Schneider, 1801. *Blochii Syst. Ichth.*: 518 (*islandicus*).
Argyctius Rafinesque, 1810. *Caratt. nuov. Gen.*: 55 (*quadrimaculatus*).
Cephalepis Rafinesque, 1810. *Ind. Ittiol. Siciliana*: 54 (*octomaculatus*).
Epidesmus Ranzani, 1818. *Opusc. Sci. Bologna*: 137 (*maculatus*).

Body elongate, compressed, scaleless ; dorsal and ventral outlines tapering more or less evenly from head to caudal fin. Recurved, pointed teeth in both jaws, 6 to 12 in the upper, 6 to 10 in the lower. Vomer with 1 to 2 median teeth. Palatine teeth, if present, feeble. Nostrils single. One dorsal fin, consisting of 145 to 190 rays, the first 5 or 6 elongate, at least in the young. Pectorals of 9 to 12 rays. Pelvics 3 to 9, long and filamentous in young stages but reduced to stumps in adults. No anal fin. Caudal fin in two parts ; the upper lobe of 6 to 10 well developed rays, often set at right angles to the longitudinal axis of the body ; the lower lobe of 2 to 7 rudimentary rays in adults. Lateral line straight, running the length of the body, armed with small forwardly directed spines which become larger posteriorly. Gill rakers on first arch 3 to 4 + 7 to 10. Branchiostegal rays 6. Vertebrae 84 to 102. Swim bladder present, much reduced in adults.

KEY TO MEDITERRANEAN AND N.E. ATLANTIC SPECIES

1. Greatest depth of body ¼ to ⅓ of the way along its length, except in specimens of less than 300 mm. ; depth of caudal peduncle contained more than twice in depth of body at 10th lateral line spine forward from the caudal fin. Body axis approximately a straight line in adults (see Pl. 62, fig. 1) . . . . . *arcticus*
2. Greatest depth of body immediately behind head ; depth of caudal peduncle contained less than twice in depth of body at 10th lateral line spine forward from caudal fin. Body axis upcurved in the posterior caudal region in adults (see Pl. 62, fig. 2) *trachypterus*

Trachipterus arcticus (Brünnich)

Trichiurus lepturus Mohr, 1786 (nec Linnaeus). *Forsøg til en Islandsk Naturhist.* Copenhagen : 63 (Iceland) ; Pálsson, 1791–97 (1945). *J. Naturf. Reise Island* : 36 and 187 (Iceland) (fide Saemundsson, 1949) ; Hoy, 1815. *Trans. Linn. Soc. Lond.* **11** : 210 (Moray Firth).
Gymnogaster arcticus Brünnich, 1788. *K. Dansk. Selsskr. N. Saml.* **3** : 408 tab. B, figs. 1–3 (Iceland) ; Faber, 1829. *Naturg. Fische Islands* : 66 (general) ; Cuvier, 1829. *Règn. Anim. Ed.* **2** : 219 (description) ; Fleming, 1831. *Ann. Mag. nat. Hist.* **4** : 215, fig. 34 (Orkneys); Nilsson, 1832. *Prod. Ichth. Scand.* : 107 (synonymy, distribution) ; Jenyns, 1835. *Brit. Vert.* : 372 (synonymy, description) ; Swainson, 1839. *Nat. Hist. Fishes, Amphib., Rept.* **2** : 258 (generic diagnoses) ; Duduid, 1851. *Proc. zool. Soc. Lond.* : 116 (Orkneys).
Bogmarus islandicus Schneider, 1801. *Blochii Syst. Ichth.* **2** : 518, pl. 101 (Iceland).
Trachypterus arcticus, Nilsson, 1855. *Skand. Faun. Fisk.* **4** : 162 (Scandinavia) ; Günther, 1861. *Cat. Fish. Brit. Mus.* **3** : 305–306 (synonymy, description) ; Collett, 1875. *Norges Fiske, Christiania* : 78 (Norway) ; Newman, 1875. *Zoologist* (2) **10** : 434 (Donegal Bay) ; Edwards, 1879. *Zoologist* (3) **3** : 220 (Banffshire coast) ; Day, 1880–84. *Fishes of Great Britain and Ireland* **1** : 217, pl. 63 (synonymy, description) ; Lütken, 1882. *Vid. Selsk. Forh.* : 206–216 (synonymy) (translated in *Ann. Mag. nat. Hist.* (5) **11** : 176–184, 1883) ; Schneider, 1882. *Vid. Selsk. Forh.* No. 15 : 1–6 fig. (Scandinavia) ; Collett, 1885. *Norges Fiske, Christiania* (2nd suppl.) : 69 (Norway) ; Meek, 1890. *Stud. Dundee Mus.* **1**, No. 6 : 1–24, 2 pls., 9 figs. (anatomy) ; Lilljeborg, 1891. *Sver. Norges Fiskar. Uppsala* **1** : 462 (synonymy, description) ; Smitt, 1893. *Scandinavian Fishes* **1** : 315, fig. (general) ; Goode and Bean, 1895. *Oceanic Ichth.* : 479, fig. (synonymy) ; Traquair, 1896. *Ann. Scot. nat. Hist.* : 159 (Shetland Isl.) ; Cnrsiter, 1896. *Ann. Scot. nat. Hist.* : 160 (Orkneys) ; Clarke, 1900. *Ann. Scot. nat. Hist.* : 13 (Firth of Forth) ; Collett, 1902–05. *Norges Fiske, Christiania* (3rd suppl.), No. 1 : 99 (Norway) ; Lemmon, 1905. *Ann. Scot. nat. Hist.* :184 (Banffshire

coast) ; Evans, 1909. *Ann. Scot. nat. Hist.* : 20 (Scottish coast) ; Cole, 1913. *Nature*, **91** : 607 (Grimsby Mkt) ; Thompson, 1918. *Scot. Nat.* : 67–68 (Rockall and St. Kilda) ; Wolleback, 1924. *Norges Fiske, Christiania* : 218 (distribution) ; ? Barnard, 1925. *Ann. S. Afr. Mus.* **21**, Pt. 1 : 353, fig. (doubtful S. African record) ; Saemundsson, 1926. *Fiskarnir, Reykjavik* : 155 (Iceland) ; Matheson, 1930. *Ann. Mag. nat. Hist.* (10) **6** : 683–685 (west of Ireland) ; Buen, 1935. *Inst. esp. Oceanogr. Not. y Res.* (2) No. 88 : 78 (Atlantic) ; Nobre, 1935. *Peixes de Portugal*, **1** : 162, fig. (Portugal) ; Ehrenbaum, 1936. *Naturg. Wirtsch. Bedeutung Seefische Nord-Europas, Stuttgart* : 153, fig. 129 (description, distribution) ; Lozano y Rey, 1947. *Fauna Iberica, Peces*, **2** : 693, fig. (key to species) ; Smith, 1949. *Sea Fishes of S. Africa* : 142 (S. African record and key to species) ; Went, 1952. *Irish Nat. J.* **10** : 302 (Ireland) ; Andryashev, 1954. *Tabl. anal. Faune URSS No.* 53 : 207, fig. (description, distribution).

Trachypterus bogmarus Cuv. and Val., 1835. *Hist. nat. Poissons*, **10** : 346 (synonymy, Norway) ; Reinhardt, 1835–1836 (1837). *K. dansk. vid. Selsk.* : 3 (Faroe Isl.) ; Bonaparte, 1846. *Cat. met. Pesci Europei* : 79 (synonymy).

Gymnetrus arcticus, Yarrell, 1836. *Brit. Fishes*, **1** : 191 (description).

Trachypterus vogmarus Reinhardt, 1838. *K. dansk. vid Selsk.* **7** : 67 (Denmark) ; Hallgrimsson, *c.* 1845 (1936). *Islenzk Dyr*, **3**, Pt. 3–5 : 98 (*fide* Saemundsson, 1949) ; Gröndal, 1891. *Pisces Islandiae* : 46 (*fide* Saemundsson, 1949).

Vogmarus islandicus, Reid, 1849. *Ann. Mag. nat. Hist.* (2) **3** : 456 (Scotland).

Trachypterus gryphurus Lowe, 1850. *Proc. Zool. Soc. Lond.* : 248 (Madeira) ; Günther, 1861. *Cat. Fish. Brit. Mus.* **3** : 301 (description) ; Goode and Bean, 1895. *Oceanic Ichth.* : 478 (description).

Trachypterus iris Priol. (nec Walbaum), 1944. *Rev. Trav. Off. Pêche marit.* **13** : 432, fig. (from *Germo* stomach, off coast of Spain).

D. 150–190 ; A. 0 ; V. 5–6 ; P. 9–11 ; C. 8 + 5–6. Branchiostegal rays 6. Vertebrae 99 to 102.

Body strongly compressed, greatest depth about midway between occiput and vent in adults, from which point the body tapers more or less evenly dorsally and ventrally to the caudal fin. Ventral profile conspicuously armed with wart-like tubercles, especially in large specimens. Anterior profile of head straight, sharply declivous in young when mouth is retracted. Eye of moderate size. Teeth in upper jaw slender, almost horizontal, their distal ends pointing backwards. Usually 6 to 12 in number. Those in the lower jaw stronger, slightly recurved, 6 to 9 in number. Three to 5 teeth on the vomer, none on the palatines. Gill rakers on first arch 3 to 4 + 7 to 10. A single dorsal fin, the first 5 or 6 rays greatly prolonged in young stages, but never with bulbous flaps. Pelvics extremely elongate in young stages, but vestigial in adults. Caudal fin in two parts, the upper lobe of 8 well developed rays, the lower lobe of 5 or 6 rudimentary rays. The upper lobe of this fin is usually set at right angles to the body axis in adults. Scales absent, except for a modified series along the lateral line, each of which is armed with a small forwardly directed spine. These spines increase in size towards the posterior end of the body. Scattered over the body are numerous small pit-like depressions, the structure and function of which have not been studied. Stüwitz (1840) figures both the lateral line scales and the pit-like depressions.

Eighteen specimens have been examined, ranging in length from 32 to 1,630 mm. The largest specimen to have been recorded in recent years is one of 2,515 mm. length, trawled near the Porcupine Bank off the west coast of Ireland.

Colour : Silvery, with usually from 1 to 5 dark spots along the body. These may completely disappear in large examples and the overall body colour become brownish. In life, the dorsal fin is red.

I have examined Lowe's unique example of *T. gryphurus* described by him in 1850 from Madeira. Although in a poor state of preservation, this specimen appears to be conspecific with examples of *T. arcticus*. The accompanying table indicates that *T. gryphurus* agrees more closely with *T. arcticus* than with *T. trachypterus*.

	gryphurus	*arcticus*	*trachypterus*
Average number of dorsal rays	170 (1)	169·5 (18)	164·8 (44)
,, ,, ,, vertebrae	100 (1)	99 (18)	90 (44)
Depth of caudal peduncle into depth of body at 10th lateral line spine forward from caudal	2·5 (1)	2·2–5 (18)	1·3–2 (44)

The number of specimens of each species examined is indicated in brackets.

The type of *T. gryphurus* is here figured for the first time.

In younger stages of *T. arcticus* (i.e. specimens below 300 mm. in length) the greatest depth of the body is immediately behind the head as in *T. trachypterus*, but whereas in *T. arcticus* this depth remains more or less constant to about $\frac{1}{3}$ of the way along the body length before the gradual tapering to the caudal begins, in young examples of *T. trachypterus* this tapering commences immediately behind the occiput.

T. arcticus is a north-eastern Atlantic species which does not seem to occur in the western North Atlantic. It has not been possible to ascertain satisfactorily its southerly limits from existing records, but it has not been reported from the Mediterranean.* There is one record from Madeiran waters and Priol (1944) figures and describes ten juvenile examples of what he calls *T. iris* from the stomach of an albacore (*Germo alalunga*), which was captured north west of Finisterre. From the information given, however, it is clear that these fishes are examples of *T. arcticus*.

The breeding areas of this species do not appear to be known, but it is probable that spawning occurs at considerable depths in off-shore waters. Andryashev (1954) states that shoals of several hundreds of these fishes may be observed off the north-east coast of Iceland, varying in length from 900 to 2,060 mm. Unfortunately, no indication is given as to whether or not this is a seasonal occurrence. In this connection, it is of interest to note the comparatively large influx of this species into Scottish waters in the year 1954 when fifteen specimens were recorded, none being less than 830 mm. in length.

It has been reported on a number of occasions by Scandinavian fishermen that they have seen these fishes floating on their sides at or near the surface. A more recent report of a similar occurrence has been made by Mr. S. Willis. In November,

* Since this paper went to press, I have seen a report by Planas and Vives (1956) which records the occurrence in the Mediterranean of three specimens of *T. arcticus*, 425–529 mm. in length.

1955, some 200 miles west of Lands End, he saw seven or eight objects of varying size floating on the surface. Closer inspection showed that they were fishes and from his description they were almost certainly examples of *T. arcticus*. He states that they were floating on their sides, moving feebly as though stunned. The reason for this behaviour is not apparent, but may be abnormal.

A juvenile example of this species has recently been received from Dr. J. H. Fraser of Aberdeen. It was taken off the west coast of Ireland (54° 10′ N., 12° 10′ W.) in an oblique haul from 250 to 0 metres. A brief description of the specimen is given below.

It is 32 mm. in standard length and appears to be one of the smallest examples of this species reported on. At this stage it is apparent that ossification of the finrays is not yet completed as the dorsal count is considerably lower than the mean for an adult of this species. Similarly, only eight pectoral rays are at present ossified. Caudad to the last stained dorsal ray and continuous with it is a lobe containing a number of thin filamentous structures, which may be actinotrichia. There is also a similar structure on the ventral surface, which is not present in the adult. The vertebral count of 99, of which 45 are pre-caudal, places this specimen as an example of *T. arcticus*. At this stage all the vertebrae are of approximately the same length. The caudal fin consists of eight rays in the upper lobe and six on the ventral lobe. The rays in this lower lobe are well developed in this specimen, although in the adult they become obsolescent, as is the case with the pelvic rays. The pectorals have eight ossified rays plus three or four which are still unossified.

Measurements and counts for this specimen are as follows :

Standard length : 32 mm.

D : 143 + unossified rays. The first five rays are elongate.

A : 0.

Pectorals : 8 + 3 or 4 which are not yet ossified.

Pelvics : 8.

Caudal : 8 + 6.

Vertebrae : 99 (of which 45 are pre-caudal).

Greatest depth, which is immediately behind the occiput, 4 in the length.

DISTRIBUTION. Eastern North Atlantic from Iceland to Madeira and into the North Sea.

Trachipterus trachypterus (Gmelin)

Cepola trachyptera Gmelin, 1788. *Syst. Nat.* **1**, Pt. 3 : 1187 (Adriatic).

Cepola iris Walbaum, 1792. *Artedi Bibl. Philos. Ichth.* **3** : 617.

Trachypterus taenia Schneider, 1801. *Blochii Syst. Ichth.* **2** : 480 (Adriatic) ; Bonaparte, 1846. *Cat. met. Pesci Europei No.* 711 : 78 (synonymy) ; Costa, 1850. *Faun. règn. Napoli*, **2** : 3, pl. ix ; Erhard, 1858. *Faun. der Cycladen, Leipzig* : 89 (Greek waters) ; Günther, 1861. *Cat. Fish. Brit. Mus.* **3** : 302 (description) ; Canestrini, 1872. *Fauna d'Italia*, Pt. 3 : 193 (description) ; Heldreich, 1878. *La faune de Grèce, Athens* : 87 (Greek waters) ; Emery, 1879. *Mem. Atti R. Accad. Lincei*, **3** : 390 (growth stages) ; Emery, 1879. *Mitt. zool. Sta.*

Naples, **1** : 581 (growtb stages) ; Giglioli, 1880. *Elenco dei Mammiferi, etc.* : 92 (Nice and Elba) ; Gogorza, 1883. *Ann. Soc. esp. Hist. nat.* **12** : 75, 78 (Mediterranean) ; Apostolides, 1883. *La pêche en Grèce, Athens* : 11, 23 (Greece) ; Carus, 1889. *Prod. Faun. medit.* : 699 (description and distribution) ; Apostolides, 1907. *La pêche en Grèce* (2nd Ed.) : 8, 16 (Greece) ; Fage, 1907. *Arch. zool. exp. gen.* (4) **7** : 73 (listed from Balearic Isl.) ; Lo Bianco, 1908–1909. *Mitt. zool. Sta. Naples*, **19** : 1, figs. (eggs and larvae) ; Jacino, 1909. *Arch. zool. Naples*, **3**, Fasc. 4 : 479 (eggs and larvae) ; Kaschkaroff, 1913. *Anat. Anz.* **44** : 214 (structure of epidermis) ; Devedjian, 1926. *Pêches et pêcheries en Turquie* : 144, fig. (Turkish coast) ; Bertin, 1929. *Bull. Soc. zool. Fr.* **54** : 164 (description) ; Sparta, 1931. *Fauna e flora del Golfo di Napoli*, **38** : 267 (young stages) ; Dieuzeide and Goeau-Brissoniere, 1940. *Bull. Sta. Aquic. Pêche, Castiglione* (N.S.), No. 1 : 81, figs. (Algeria) ; Dieuzeide, Novella and Roland, 1954. *Bull. Sta. Aquic. Pêche, Castiglione* (N.S.), No. 5 : 146, figs. (description, distribution).

Gymnetrus cepedianus Risso, 1810. *Ichth. Nice, Paris* : 146, fig. (Mediterranean) ; Risso, 1826. *Hist. nat. Europ. mérid.* **3** : 295 (description).

Argyctius quadrimaculatus Rafinesque, 1810. *Caratt. alcun. nuov. Gen. Siciliana* : 55 (Sicily).

Cephalepis octomaculatus Rafinesque, 1810. *Indice ittiol. Siciliana* : 55 (Messina) ; Swainson, 1839. *Fishes, Amphib. Rept.* **2** : 404 (description)

Epidesmus maculatus Ranzani, 1818. *Opusc. Sci. Bologna*, **2** : 133, pl. 6 (Adriatic).

B(r)ogmarus aristotelis Risso, 1820. *J. Phys. Chim. Hist. nat. Paris*, **91** : 249 (Nice).

Bogmarus mediterraneus Otto, 1821. *Conspic. Anim.* : 6 (Mediterranean).

Regalecus maculatus, Nardo, 1824. *Giorn. Fisica, Pavie*, 8 : 116 (not seen ; fide Costa, *Faune Règne Napoli*).

Trichiurus trimaculatus Giovene, 1829. *Mem. Soc. ital.* **20**, Pt. 1 : 25 (Mediterranean).

Trachypterus spinolae Cuvier and Valenciennes, 1835. *Hist. nat. Poissons*, **10** : 328 (Nice) ; Bonaparte, 1846. *Cat. met. Pesci Europei*, No. 712 : 79 (synonymy ; Mediterranean) ; Canestrini, 1861. *Arch. Zool. Anat. Fis. Genova*, **1**, Fasc. 1 : 26 (Gulf of Genoa) ; Günther, 1861. *Cat. Fish. Brit. Mus.* **3** : 300 (description and distribution) ; Canestrini, 1872. *Fauna d'Italia*, Pt. 3 : 193 (Naples, Sicily) ; Giglioli, 1880. *Elenco dei Mammiferi, etc.* : 91 (Nice, Elba, Naples) ; Moreau, 1881. *Hist. nat. Poissons*, **2** : 565, fig. (description and synonymy) ; Bertin, 1946. *Petit Atlas des Poissons*, **1** : 81, fig. (brief diagnosis).

Trachypterus falx Cuvier and Valenciennes, 1835. *Hist. nat. Poissons*, **10** : 333 (Spain) ; Moreau, 1881. *Hist. nat. Poissons*, **2** : 558 (description and synonymy) ; Fage, 1907. *Arch. Zool. exp. gén.* (4) **7** : 73 (listed from Balearic Islands).

Trachypterus iris, Cuvier and Valenciennes, 1835. *Hist. nat. Poissons*, **10** : 341, pl. (Adriatic) ; Günther, 1861. *Cat. Fish. Brit. Mus.* **3** : 303 (description, distribution) ; Canestrini, 1861. *Arch. Zool Anat. Fis. Genova*, **1**, Fasc. 1 : 262 (Gulf of Genoa) ; Carruccio, 1870. *Cat. degli Anim. Sicilia* : 32 (Cagliari) ; Emery, 1879. *Zool. Sta. Napoli*, **1** : 581 (young stages) ; Giglioli, 1880. *Elenco dei Mammiferi, etc.* : 92 (Livorno, Elba and Cagliari) ; Moreau, 1881. *Hist. nat. Poissons*, **2** : 561 (description, synonymy) ; Goode and Bean, 1895. *Oceanic Ichth.* : 477, fig. (description, synonymy) ; Damiani, 1896. *Riv. ital. Sci. nat. Siena*, **16** : 132 (Genoa) ; Parona, 1898. *Atti Soc. Ligust. Sci. Genova*, **9** : 350 (Ligurian Sea) ; Barnard, 1925. *Ann. S. Afr. Mus.*, **21** : 353 (S. Africa) ; Buen, F. de, 1926. *Res. Camp. Inst. esp. Oceanogr.* No. 2 : 72 (Catalan Sea, Balearic Isl.) ; Mourgue, 1931. *Bull. Soc. Linn. Lyon*, **10** : 39 (abundance in Mediterranean) ; Kamohara, 1934. *Zool. Mag. Tokyo*, **46** : 462, fig. (Japan) ; Buen, F. de, *Inst. esp. Oceanogr. Not. y Res.* (2), No. 88 : 78 (Mediterranean) ; Ninni, 1939. *Atti Soc. ital. Milan*, **78** : 224 (synonymy) ; Matsubara, 1941. *Suisan Kenkiushi Japan*, **36**, No. 2 : 34 (Japan) ; Lozano y Rey, *Fauna Iberica Peces*, **2** : 686, figs. (description, synonymy) ; ? Barnard, 1947. *A pictorial guide to S. African fishes, Cape Town* : 84, pl. X, fig. 2 (Table Bay ; the figure is that of *T. arcticus*) ; King and Ikehara, 1956. *Pac. Sci.* **10** : 22–23 (Central Pacific).

Trachypterus leioptcrus Cuvier and Valenciennes, 1835. *Hist. nat. Poissons*, **10** : 342 (Naples and Nice) ; Günther, 1861. *Cat. Fish. Brit. Mus.* **3** : 304 (description, distribution) ; Giglioli, 1880. *Elenco dei Mammiferi, etc.* : 92 (Nice, Genoa, Messina) ; Moreau, 1881.

Hist. nat. Poissons, **2** : 563 (description, synonymy) ; Carus, 1889–1893. *Prod. Faun. Médit.* : 700 (description, distribution) ; Goode and Bean, 1895. *Oceanic Ichth.* : 479 (general notes) ; Damiani, 1896. *Riv. ital. Sci. nat. Siena*, **16** : 132 (Genoa) ; Parona, 1898. *Atti Soc. Ligust. Sci. Genova*, **9** : 350 (Ligurian Sea) ; Tortonese and Trotti, 1950. *Atti Acad. Ligure*, **6** : 99 (Ligurian Sea).

Trachypterus costae Cocco, 1838. *Giorn. Il Faro*, **4**, Anno 6 : 4, figs. 1a and b. (Messina).

Cephalepis swainsonii Rafinesque in Swainson, 1839. *Fishes, Amphib. Rept.* **2** : 404 (Sicily).

Trachypterus rondeletii Costa, 1850. *Fauna Regn. Napoli*, **2** : 10, fig. IX bis (Naples).

Trachypterus rüppellii Günther, 1861. *Cat. Fish. Brit. Mus.* **3** : 304 (Mediterranean) ; Carus, 1889–93. *Prod. Faun. Médit.* : 700 (description) ; Goode and Bean, 1895. *Oceanic Ichth.* : 479 (references copied).

Trachypterus trachypterus, Hamilton, 1916. *Trans. Proc. N.Z. Inst.* **48** : 374, figs. (review of New Zealand species) ; Pietschmann, 1925. *Veroff. naturhist. Mus. Wien*, **5** : 6, figs. (popular account) ; Phillipps, 1927. *Fish. Bull. Wellington, N.Z.*, No. 1 : 26 (listed from New Zealand) ; Fowler, 1936. *Bull. Amer. Mus. nat. Hist.* **70** : 492 (description) ; Tortonese, 1948. *Bol. Pesca Piscic. Idrobiol.* **23** (N.S.) **2** : 19 (Aegean Sea) ; Tortonese and Trotti, 1950. *Atti Accad. Ligure*, **6** : 99 (Ligurian Sea) ; Tortonese, 1952. *Natura, Milan*, **43** : 28 (Ligurian Sea).

Trachypterus pentastigma Norman, 1922. *Ann. Mag. nat. Hist.* (9) **10** : 217 (Japan) ; Matsubara, 1941. *Suisan Kenkui-shi*, **36**, No. 2 : 34 (affinities).

Trachypterus arcticus, Barnard (nec Brünnich), 1948. *Ann. S. Afr. Mus.* **36** : 359, fig. (S. Africa).

D. 145–185; A. 0; V. 5; P. 9–11 ; C. 8 + 5 rudiments; branchiostegal, rays 6 ; Vertebrae, 84–96.

This species occurs in large numbers in the Mediterranean, which appears to be one of its main spawning areas. Eggs and larvae, as well as adults, have been recorded from this sea on many occasions. It has also been recorded from Japan (Norman, 1922 ; Kamohara, 1934 and Matsubara, 1941) and New Zealand (Hamilton, 1916 ; Phillipps, 1927).

I have examined the type of *T. pentastigma* described by Norman (1922) from Misaki, Japan, and have come to the conclusion that Matsubara (1941) was correct in synonymizing this species with *T. trachypterus*. A comparison of this specimen with one of equal length from the Mediterranean shows that there is no significant difference in vertebral or fin-ray counts. There is a difference in the proportional body depth of the two examples, the Mediterranean specimen having a slightly deeper body. This character, however, is a known variable in this group of fishes and it is also obvious from the proportions given by Norman that the Japanese example has shrunk appreciably since being examined by him. This specimen has a pattern of five dark blotches along the side of the body, whereas *T. trachypterus* has usually three to four of these markings. This is not constant, however, as several of the Mediterranean specimens which I have examined also show a pattern of five dark blotches.

It may be noted that *T. pentastigma* appears to be very similar, both in meristic counts and in markings, to *T. rex-salmonorum* described from San Francisco Bay by Jordan and Gilbert (1894) of which *T. seleniris* Snyder (1908) from Monterey Bay, California is a synonym. *T. arawatae* Clark (1880) from New Zealand may well be synonymous with the above, but these records are all outside the area covered in this paper.

There is an important error in the original description of *T. pentastigma*, Norman stating that the jaws of the specimen are without teeth. A careful examination of the holotype, however, reveals the presence of slender teeth in both jaws, the number and form of which are similar to those found in other specimens of *Trachipterus*.

The large specimen from the Mediterranean described by Günther (1861) as *T. rüppellii*, although in a poor state of preservation, is undoubtedly an adult example of *T. trachypterus*. I have been unable to find any characters that could warrant this specimen being considered specifically distinct.

Barnard (1947) mentions and figures specimens from South Africa, which he considers to be examples of *T. trachypterus*. I include these records with some hesitation as I believe that they are more properly referable to the Australian species *T. jacksonensis*. The same author (1948) lists a fully grown female under the name *T. arcticus*. It is clear from the figure that this specimen is an example of *T. trachypterus* and Barnard himself indicates some doubt as to the specific identity of this fish. King and Ikehara (1956) record an example of *T. trachypterus* from the Central Pacific.

Fourty-four specimens have been examined, ranging in length from 81 to 1,700 mm. The coloration and markings are similar to those of the previous species.

DISTRIBUTION. Mediterranean, S. Africa, Central Pacific, Japan, New Zealand.

Zu Walters and Fitch

Zu Walters and Fitch, 1960. *Calif. Fish Game*, **46** : 445

Body elongate, laterally compressed. The caudal region sharply constricted dorso-ventrally behind the vent. Twelve to 18 strong caniniform teeth in the upper jaw, 8 to 12 in the lower jaw, with smaller teeth at the symphysis. Vomer with 4 strong teeth, both palatines with 3 teeth. Nostrils as in *Trachipterus*. Dorsal fin consisting of 120 to 150 rays, the first 5 elongate. Pectorals with 11 to 12 rays, pelvics with 3 to 6 rays, present at all stages. No anal fin. Caudal fin in two parts, the upper fan-like of 8 to 12 rays, the lower of 1 to 5 rays. These latter are reduced, but are not rudimentary as in *Trachipterus*. Ventral edge of body not covered with wart-like tubercles. Lateral line armed, straight as far as the ventral constriction where it joins the lower edge of the body. Posteriorly from this point the ventral edge of the caudal region is armed with an additional paired series of downwardly directed spines, one on either side of the body. Deciduous cycloid scales present. Gill-rakers on first arch $3 + 1 + 8$. Branchiostegal rays, 6. Vertebrae, 64–65. Swim bladder present, though much reduced in adults. In young stages bulbous flaps are present on the elongate dorsal and pelvic rays.

Type : *Trachypterus cristatus* Bonelli, 1820.

DISTRIBUTION. Mediterranean ; S. Atlantic ; Indo-Pacific ; Japan.

Closely related to *Trachipterus*, from which it differs in having fewer vertebrae and a stronger dentition, in the presence of scales and in the shape of the ventral profile of the body and of the caudal fin.

Zu cristatus (Bonelli)

Trachypterus cristatus Bonelli, 1820. *Mem. Acad. Sci. Turin*, **24** : 487 (Gulf of Spezia) ; Günther, 1861. *Cat. Fish. Brit. Mus.* **3** : 301 (description) ; Giglioli, 1880. *Elenco dei Mammiferi, etc.* : 91 (Nice) ; Moreau, 1881. *Hist. nat. Poissons*, **2** : 567 (description, distribution) ; Carus, 1889–1893. *Prod. Faun. Médit.* : 700 (description, distribution) ; Goode and Bean, 1895. *Oceanic Ichth.* : 479 (description, distribution) ; Parona, 1898. *Atti Soc. Ligur. Sci. Genova*, **9** : 350 (Ligurian Sea) ; Fage, 1907. *Arch. Zool. exp. gén.* (4) **7** : 73 (listed from Balearic Islands) ; Sanzo, 1918. *Mem. R. Como Talass. ital. Venice*, **64** : 1–15 (eggs and larvae) ; Argilas, 1928. *Bull. Sta. Aquic. Pêche Castiglione Fasc.* **1** : 27, 2 figs. (Algeria) ; Sparta, 1931. *Fauna e Flora del Golfo di Napoli*, **38** : 272 (young stages) ; Stephanidis, 1939. *Acta Inst. Mus. zool. Univ. Athens*, **2** : 246, fig. (Greek waters) ; Lozano y Rey, 1947. *Mem. R. Acad. Cienc. Madrid*, **9** : 689 (description, distribution) ; Smith, 1949. *Ann. Mag. nat. Hist.* (12) **2** : 99 (Durban) ; Smith, 1949. *Sea Fishes of Southern Africa* : 142, fig. (description, distribution) ; Tortonese and Trotti, 1950. *Atti Acad. Ligure*, **6** : 99 (Gulf of Spezia) ; Dieuzeide, Novella and Roland, 1954. *Bull. Sta. Aquic. Pêche Castiglione* (N.S.), No. 5 : 151, figs. (Algeria) ; Tortonese, 1958. *Doriana*, **2**, No. 89 : 1–5 (Ligurian Sea).

Gymnetrus repandus Metaxa, 1833. *Ann. Med. Chirug. Roma Fasc.* **1** : 53 (Gulf of Naples).

Trachypterus bonelli Cuvier and Valenciennes, 1835. *Hist. nat. Poissons*, **10** : 331 (Mediterranean) ; Canestrini, 1862. *Arch. Zool. Anat. Fis. Genova*, **1**, Fasc. 1 : 266 (Gulf of Genoa).

Gymnetrus müllerianus Risso, 1840. *Arch. naturgesch. Berlin*, **6** : 13 (Nice).

Trachypterus repandus, Costa, 1850. *Fauna Regn. Napoli*, **2** : 11, pl. (Mediterranean) ; Bonaparte, 1846. *Cat. met. Pesci Europei* : 79 (synonymy) ; Steindachner, 1868. *S.K. Akad. Wiss. Wien*, **57** : 676 (Alicante) ; Canestrini, 1871–72. *Fauna d'Italia Pesci* : 194 (description) ; Giglioli, 1880. *Elenco dei Mammiferi, etc.* : 92 (Naples) ; Goode and Bean, 1895. *Oceanic Ichth.* : 480 (description) ; Pietschmann, 1925. *Veröff. naturhist. Mus. Wien*, **5** : figs. 1–3.

Trachypterus iris Buen (nec Walbaum), 1917. *Bol. Pesca Madrid*, **2** : 23–26, 2 figs. (description, distribution).

Trachypterus gavardi Bounhiol in Bounhiol and Gavard, 1923. *Bull. Inst. Oceanogr. Monaco*, No. 432 : 1–4 (Bay of Algiers) ; Weber and de Beaufort, 1929. *Fishes of the Indo-Australian Archipelago*, **5** : 91 (references).

D. 120–150 ; A. 0 ; V. 6 ; P. 11 ; C. 8 + 4 ; Branchiostegal rays 6 ; Vertebrae 64–65 ; Gill rakers 3 + 1 + 8.

This species is markedly different from both species of *Trachipterus*, as indicated in the generic description. The most obvious character is the shape of the ventral profile, which is scalloped and sharply constricted at the vent in this species, a difference which is present in specimens of 30 mm. length upwards. It would appear to attain to the same length as *T. trachypterus*, the longest specimen I have seen recorded being 1,105 mm. in total length. This specimen was captured near Genoa and reported on by Tortonese (1958). The body in this species is more robust and the dentition stronger than in *Trachipterus*.

Zu cristatus is found in the Mediterranean, from which area all stages have been taken on numerous occasions. Outside the Mediterranean it has been reported from Madeira and the Azores, with one record from Durban, S. Africa.

I have examined a larval form 32 mm. in standard length, taken by the " Challenger " near the Philippines and reported on by Günther (1887) and another specimen 31 mm. in standard length, taken by the " Discovery " off the Cape of Good Hope (33° 30′ S., 17° 29′ E.). Both these specimens are morphometrically indis-

tinguishable from *Zu cristatus*, and it may be that the genus *Zu* is monotypic. Confirmation of this fact, however, must be left for Walters *et al.* It is for this reason that I have not included *T. ijimae* Jordan and Snyder 1901 from Japan or *T. semiphorus* Bleeker 1868 from Amboina in the synonymy of *Zu cristatus*.

The colour pattern of this species is quite distinctive and consists of six or seven incomplete dark wavy vertical bars dorsally, with three or four similar markings on the ventral edge of the body. On the caudal region there are six or seven entire vertical dark bands. The body is silvery, as in *Trachipterus*, but with the addition of deciduous cycloid scales. The caudal fin is usually dark brown to black in preserved material.

Twenty-six specimens have been examined, ranging in length from 31 to 655 mm.

Distribution. Mediterranean, Madeira, Azores, Durban, ? Cape of Good Hope, ? Philippines, ? New Zealand.

Young stages of Trachipterid fishes

Having had the opportunity of examining a number of young examples of each of the three species dealt with here, it is evident that the characters present in the young of this group persist until a definite developmental stage is attained. This does not appear to be directly correlated with size alone, as in some instances smaller sized individuals show fewer juvenile characters than other specimens of larger size. In the majority of specimens examined, this change takes place within the size limits of 50 and 70 mm. On the other hand, there is an example of the genus *Zu* from the Philippines of 38 mm. length in which almost all trace of the juvenile characters has already been lost. This suggests that the post larvae are pelagic and that a triggering process is needed to set in motion this partial metamorphosis.

In specimens prior to this stage, the first 5 or 6 dorsal rays and the first 3 or 4 pelvic rays are greatly elongated, the caudal fin is still parallel to the body axis and has not yet separated into the distinct upper and lower lobes found in the adult. Not all the pectoral rays are fully ossified and this applies also to the rays of the dorsal fin. Posteriorly there is a fin fold supported by actinotrichia. On the ventral surface, opposite this posterior part of the dorsal fin, is a similar lobe. As members of the family Trachipteridae do not possess an anal fin, the very numerous and closely aggregated structures present in this ventral lobe, which show no basal supports, are probably actinotrichia giving added strength to this structure whilst it is of use to the larvae. Later, during the transitional stage from larva to adult, the lobe is probably sloughed off or resorbed.

This is the condition mentioned by Clarke (1880) in his description of *T. arawatae* from New Zealand. These two lobes, which he describes as dorsal and anal adipose fins, are the main characters used to distinguish this form from related species. It should be noted that these larval characters were still present in Clarke's specimen, which had attained a length of 65 mm. Ehrenbaum (1905) mentions the presence of these lobes and both Emery (1879) and Smitt (1893) indicate the presence of a similar structure in their figures of the young stages of *T. trachypterus*.

Finally, there is the growth that occurs in the vertebral column. In the juvenile stages the caudal vertebrae are the same length as those anteriorly, but with growth they elongate until in the adult they become two to four times as long as the anterior vertebrae.

Sexual dimorphism in the Trachipteridae

Although sexual dimorphism may be present in this group of fishes, I have not been able to show its occurrence from the material available to me. Attention must be drawn, however, to the statement made by McCann (1953) in which he says that such dimorphism does occur, as he has based these remarks on quite erroneous grounds. He figures two undoubted examples of the genus *Zu* and comments on other previously described specimens of the same genus, all of which he regards as males of *Trachipterus arcticus*, on the basis of a dissection made on one example of what he terms an aberrant juvenile form.

Food of Trachipterid Fishes

A few authors have commented on the food of these fishes, although the majority of those captured usually have an empty gut. It is clear, however, that they are carnivorous. Moreau (1881) states that they feed on molluscs and small crustaceans. McCann (*l.c.*) states that he has found the " whitebait " stage of other fishes in stomach contents of *Trachipterus* taken in New Zealand waters. Of the fifty or so specimens which I have had the opportunity of examining, only three contained identifiable remains in the gut. These consisted of a fairly complete example of an isospondylid fish, *Microstoma* sp., from a specimen taken off Madeira ; a mass of penaeid prawns, *Penaeus duodecimalis*, and several squid beaks, probably *Loligo*, from two further specimens taken in the Mediterranean.

Swim Bladder

It is known that the fishes of the order Allotriognathi possess a physoclistic swim bladder (Regan, 1907 and Berg, 1947) and this condition has been verified in the genera *Lophotes* and *Velifer*. The position appears to be somewhat uncertain, however, so far as the Trachipteridae are concerned. Of the several authors who have published accounts of the anatomy of these fishes Meek (1890), in describing an example of *T. arcticus*, makes no mention of the presence of a swim bladder. Other authors, notably Reid (1849), Smitt (1893) and Andryashev (1954), state quite definitely that this organ is absent. As already mentioned Regan and Berg, in their definition of the order, state that a swim bladder is present but make no further reference to it in the diagnosis of the family.

In view of these conflicting statements I have examined two or three half-grown and adult specimens of *T. arcticus*, *T. trachypterus* and *Zu cristatus* of varying sizes, together with a large example of *Regalecus* and have found that a swim bladder has been present in each specimen. It is a small rudimentary structure, having the appearance of a sac-like swelling, which lies dorsal to the oesophagus and a little

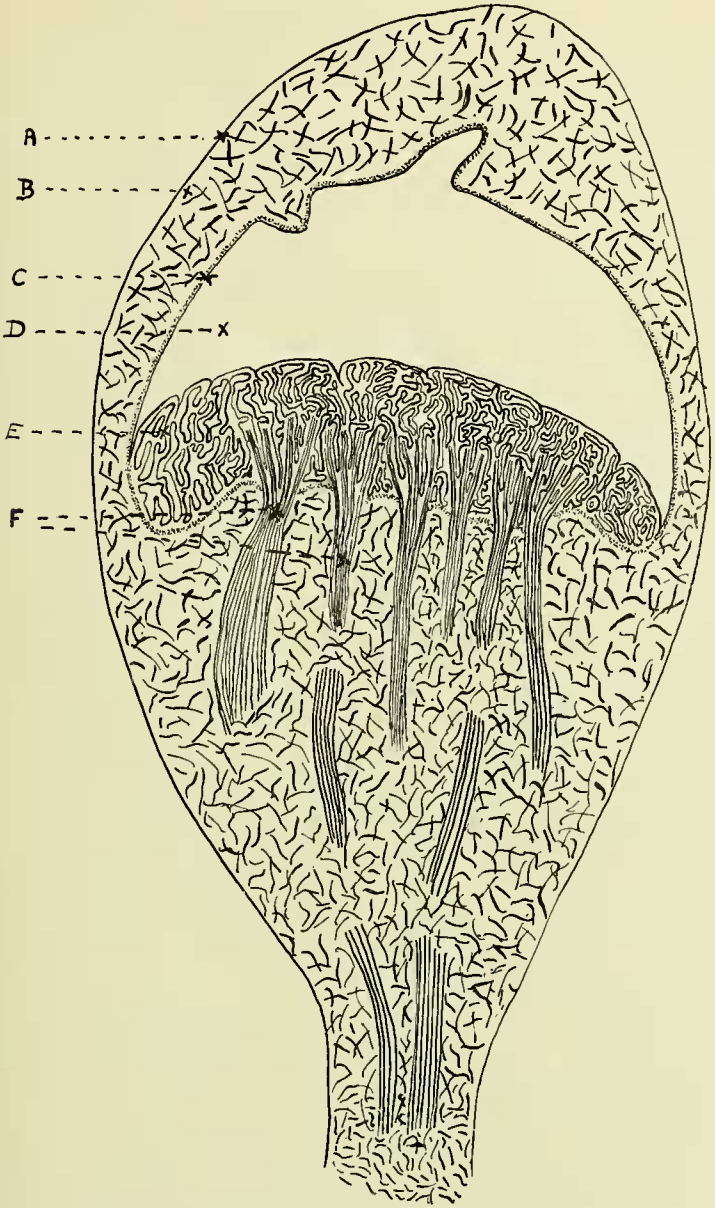

FIG. 3. Composite T.S. of swim bladder. A. tunica externa; B. submucosa; C. inner epithelium; D. lumen; E. gas gland; F. retia mirabilia.

to the right of the median line. In a specimen of *T. trachypterus* of 1,075 mm. length, the swim bladder is approximately 8 mm. long. It is, therefore, not readily visible except when dissecting the fish from the right-hand side. Stained transverse sections of this structure show quite clearly, despite the regressed condition, the presence of a gas gland with six or seven retia entering it. A small lumen is also present (Text-fig. 3).

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PLATE 62

FIG. 1. *Trachipterus arcticus*. Photograph of the holotype of *Trachipterus gryphurus* Lowe. × $\frac{1}{3}$.

FIG. 2. *Trachipterus trachypterus*. Photograph of the holotype of *Trachipterus pentastigma* Norman. × $1\frac{1}{3}$.

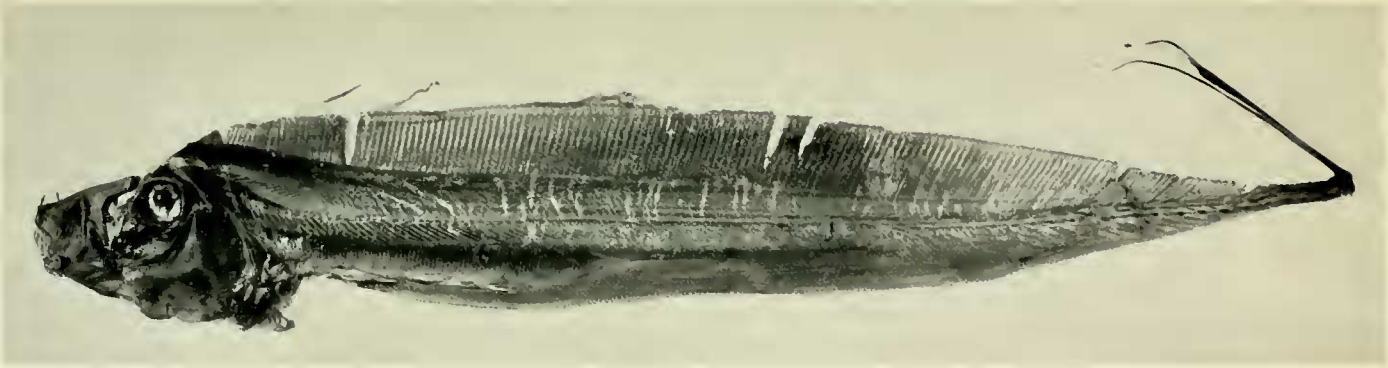

FIG. 1.

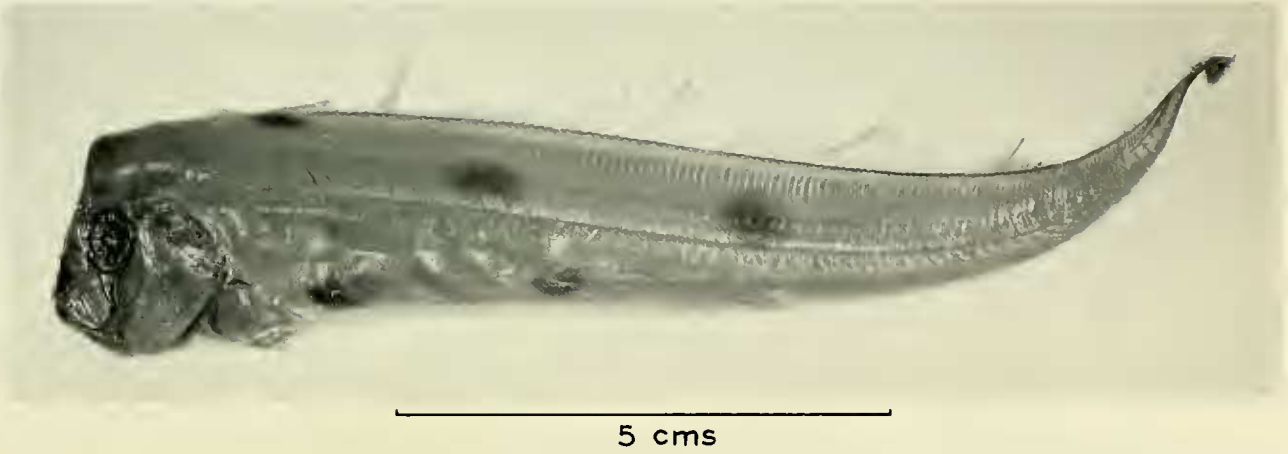

FIG. 2.